INTEGRATED BUILDING SIMULATION TOOL - RIUSKA

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ABSTRACT

A new integrated simulation system for the building services design and facilities management purposes is being developed by Insinööritoimisto Olof Granlund Oy. The system covers the thermal simulation needs of the whole building life cycle from the preliminary design to renovations. The main components of the simulation system are a simulation database, user interfaces, a result module, a building geometry modeller and a calculation engine. The building geometry modeller generates a 3-D surface model of the building. The calculation engine of the first version is DOE 2.1E. The simulation database is linked to other design databases and design programs so that redundant input data is avoided.

BACKGROUND

The RIUSKA-development project started in summer 1996. The project is funded by the Finnish Ministry of Trade and Industry and Insinööritoimisto Olof Granlund Oy. The project will last three years. The development work is done by the R&D department of Insinööritoimisto Olof Granlund Oy.

Insinööritoimisto Olof Granlund Oy is an engineering firm with 170 employees and with main business areas in building services design, energy audits, computerised facilities management systems and consulting.

INTRODUCTION

The most important decisions concerning the building energy usage are done already in the very beginning of the building design process [2]. Appropriate building simulation tools are useful tools when making these decisions (e.g. building lay-out alternatives and different basic building services systems). The input data for the simulations are mainly assumptions (e.g. internal loads) and typical solutions (e.g. typical constructions). In these preliminary studies, the focus is mainly on the differences between different design alternatives.

The calculations should be performed effectively and the results should be in a form that can be understood by a non-expert.

When the building design process continues, thermal simulation tools are needed again when selecting and sizing the systems and equipment for the building. At this phase the input values are much more accurate than in the previous design phase, and the results of the calculations should be rather accurate as the equipment and systems selections are based on these values. The user should be able to tailor the layout of the results according the special needs of the project.

In the end of the building design process, the designer calculates target values for the building energy consumption, and calculations are based on the actual building data. Results should be accurate as the real energy consumption values are compared to simulation results.

During the building operational phase facilities management personnel should be able to analyse beforehand what effects operational changes (e.g. changes in the running hours of an AC-unit or in the internal loads due to new occupants) will have on the energy consumption and the indoor air thermal quality of the building. With help of an easy-to-use simulation tool it would be possible to analyse alternatives and to choose economical energy management strategies.

A simulation tool that would fulfil all these tasks does not exist on the market. Tools designed for the first phases of the design are not accurate enough for actual design, and tools suitable for designers are not suitable for facilities management personnel. Thus Insinööritoimisto Olof Granlund Oy decided to start a project in which an in-house integrated simulation tool RIUSKA will be developed. The idea of RIUSKA is to use the same core simulation system throughout the building life cycle. Only the user interface of the system varies according to the level of the user's know-how and needs.

The simulation system will be linked to the design databases of Insinööritoimisto Olof Granlund Oy and thus the data input to the simulation program will be mainly automatic. The tool will become part of the company internal project management system.

Another main idea in RIUSKA-project is to reuse existing simulation engines, as we call the actual program, which is performing the thermal balance equations of the building. In the first prototype of RIUSKA, DOE 2.1E was chosen to be the simulation engine. DOE was chosen because it is a widely accepted building thermal simulation program around the world and it includes most of the needed modules for engineering purposes.

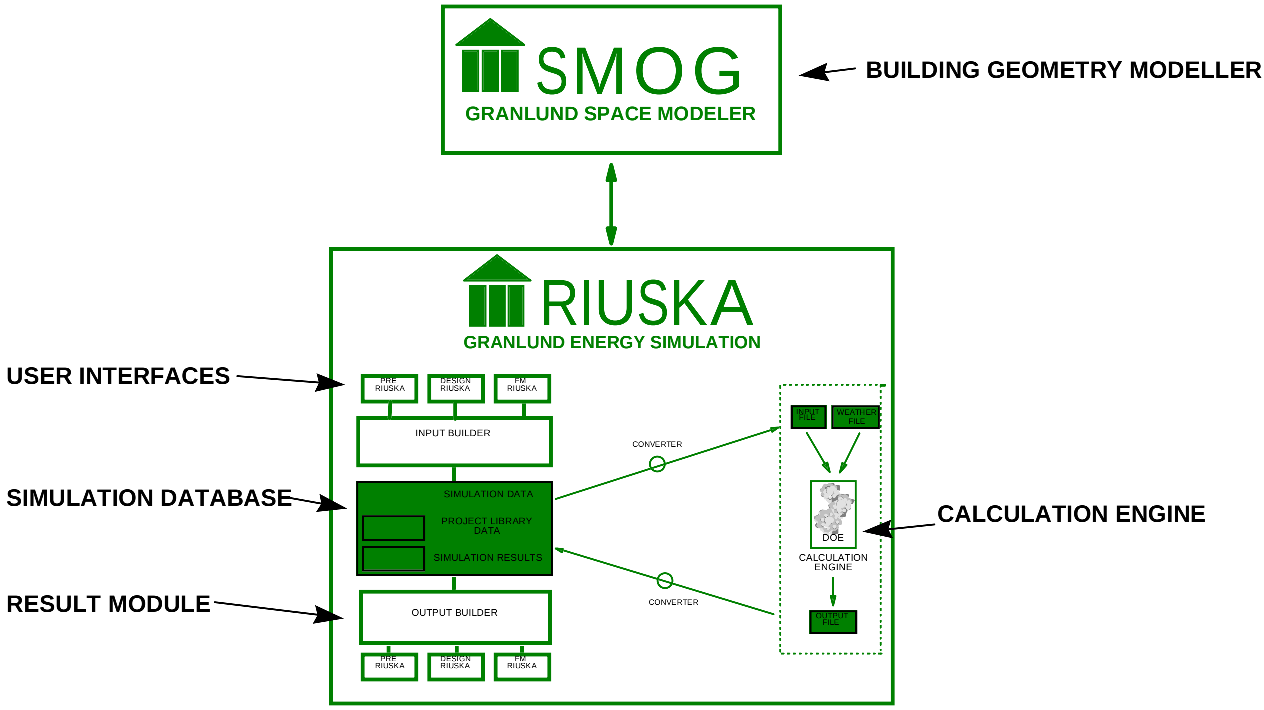

Figure 1. RIUSKA system description

SYSTEM DESCRIPTION

The main components of the simulation system are a simulation database, user interfaces, a result module, a building geometry modeller and a calculation engine. The system structure is presented in figure 1.

The database

The core of the simulation system is the simulation database. The structure of the data management system is partly based on research projects as COMBINE [1] and Raket T-611 [2] and the development work done by Insinööritoimisto Olof Granlund Oy. Experiences gained in the COMBINE project were the starting point for the development work. RIUSKA was aimed to be in use in the design work not more than one year from the beginning of the programming work. This could only be achieved by a rather simple database implementation approach compared to COMBINE. The RIUSKA database structure only represents data to be used for one application area i.e. thermal simulations.

The database also includes the results from the simulations. Thus the simulation results may be reviewed anytime together with the input values.

Later, when the standardisation of the building data can be utilised, standard data formats for data transfer (as IFC or STEP) are planned to be implemented in the RIUSKA.

The simulation database is linked to other design databases and design programs so that redundant data is avoided. The same data can be used by the HVAC-designer for the calculation of the cooling loads and the by the electrical designer for the dimensioning of the electricity distribution system.

The data sharing can be extended to interdisciplinary design data exchange (e.g. the HVAC-designer will use occupancy data defined in the architect’s design databases).

Another example of data sharing via databases is a life cycle cost calculation tool that will use energy consumption values calculated by the simulation tool.

The implemented database structure is presented in appendix 1.

User interfaces

RIUSKA will have different user interfaces for different purposes.

The user interface includes default value generation routines. If some input data is missing, default values for the missing data is generated according to the rules based on statistical data, know-how and library values.

At this moment the development is concentrating on the the user interface for the design phase. User interface for facilities management will be available during the spring of 1998. Figures 2a and 2b shows examples of the user interface for the design phase.

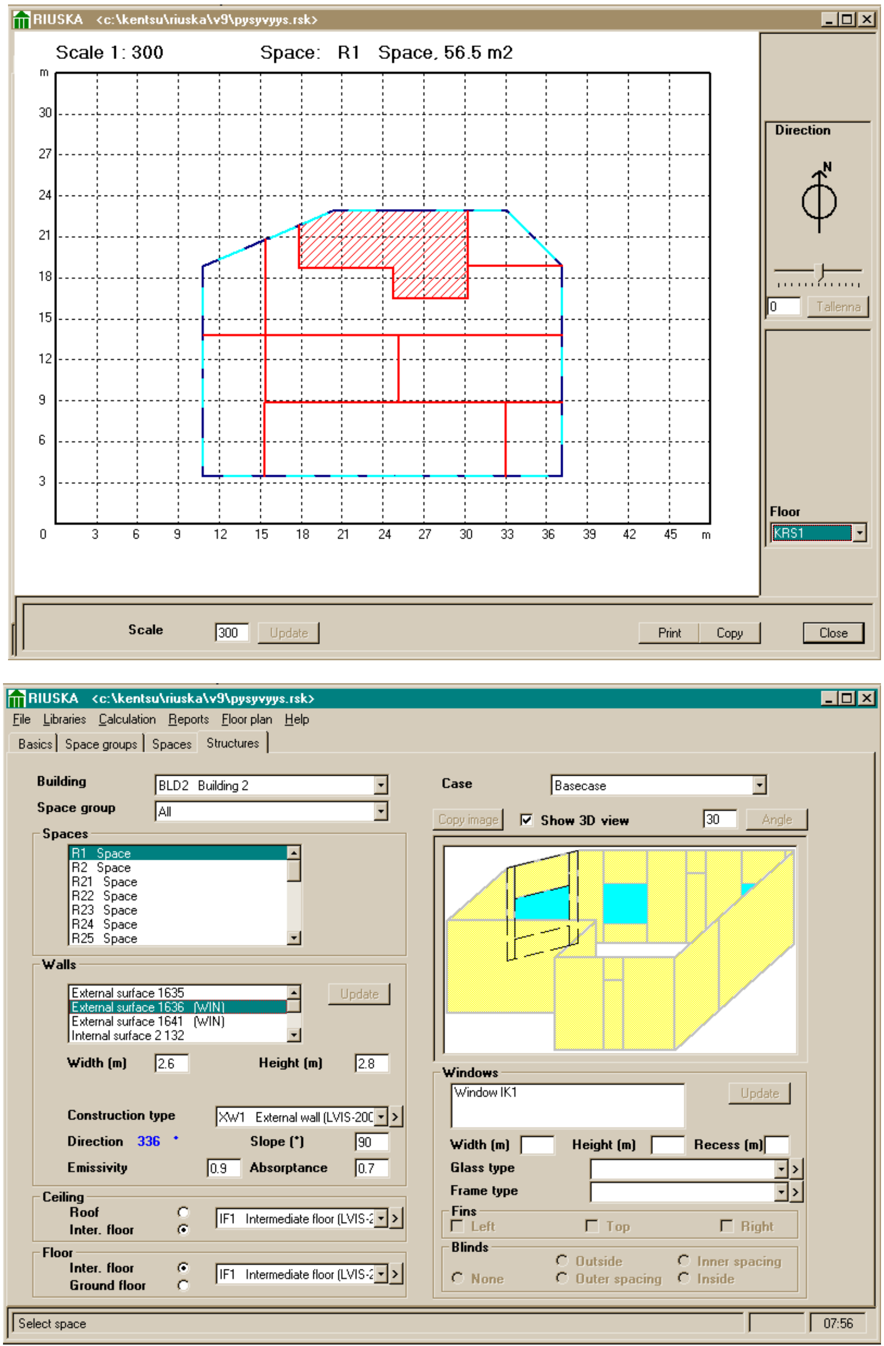

Figure 2a,b. An example of selecting a room and its structures in the RIUSKA interface for the design phase.

The result module

Simulation results can be viewed within the program and with a stand-alone result viewing application. Thus the designer can view and compare different simulations with a light and easy-to-use program. This also enables a team work method in which the experts do the simulations and designer only study the results of different simulations.

The building geometry modeller

The most novel part of the simulation system is a space modelling tool called SMOG (Space Modeller by Olof Granlund Oy). SMOG is an AutoCAD-based modelling tool which enables easy generation of the geometrical model of the building. It makes the geometry input reliable, fast and easy. SMOG creates

3-D objects of walls, windows, doors and spaces and also creates connections between these objects. For example a wall object knows its neighbour objects, and a space object knows all its wall objects.

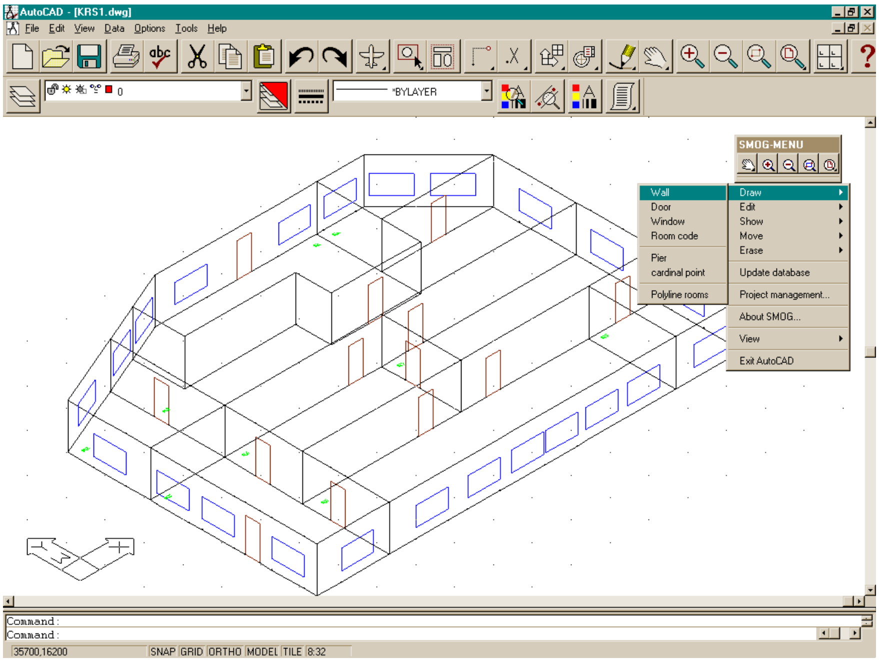

Figure 3. An example of the SMOG interface

SMOG allows users to :

- draw basic objects such as walls, windows and doors
- move and edit objects, the SMOG modeller maintains connections between objects and updates properties related to these objects (e.g. changes space areas when you move a wall)
- analyse areas quickly and efficiently
- calculate statical heat losses
- visualise the building

The users can export the 3-D objects to be used in special visualisation programs.

Figure 3 shows a view of the SMOG interface.

Area calculation

SMOG calculates user defined areas by an area calculation algorithm. Areas can be of arbitrary shape. The user can select the method how to calculate gross- and net areas (e.g. are columns includes in the net area calculation).

Database connectivity

SMOG creates an external building geometry database that is used for the data transfer to different applications. One of these applications are RIUSKA. SMOG is equipped with a DLL-module (Dynamic Link Library) to make the implementation of data transfer easier. This module makes the tool open to any application needing a simple 3D building model.

The calculation engine

The calculation engine in the first version of RIUSKA is DOE 2.1E. DOE was chosen because it is widely known among Building Services designers around the world, and it is well optimised for building services engineering purposes in terms of calculation accuracy and calculation time. Also the support and development strategy for this selected calculation engine are reasonably good.

The calculation engine is a standalone module that reads data from and sends data to the database through ASCII-files. This approach does not demand any changes to be made to the actual calculation engine.

Thus the calculation engine can be changed by writing new converters for a new calculation engine.

In the future versions of RIUSKA, DOE 2.2 will be used as the simulation engine. Other simulation engines will be implemented if needed.

FUTURE WORK

At the moment, RIUSKA is already used in design projects for room simulations and the development work is concentrating on more extensive calculation tasks such as building simulations and system simulations.

The next phases will be the implementation of the facilities management simulation during 1998.

Future ideas for the project are:

- integration of the building automation and facilities management simulation
- development of modules to be used in the commissioning phase
- implementation of energy generation calculations and energy storage calculations

CONCLUSIONS

It is possible to use dynamic thermal simulations in every-day design. The data input for the simulations should be as easy as possible. This can be achieved by reusing data from other applications, by a wide use of library data and by using CAD tools for the building geometry input. By integrating the simulation applications into the company project management system, all documents produced becomes part of the company internal document handling system and thus provides links to the quality assurance system.

REFERENCES

[1] COMBINE-project, http://erg.urd.ie/combine.html

[2] Jokela M, Keinänen A, Lassila K and Lappalainen V, ”Energy Calculation Programs And Data Management In The HVAC Life Cycle Process”, Oct 1996

[3] RATAS-project, http://www.vtt.fi/cic/cic.html

[4] ISO/STEP, http://erg.cstb.fr/ILC/ap228

[5] IFC, http://www.interoperability.com

[6] DOE 2.1E Program documentation and manuals

Appendix 1. The Simulation Database Structure